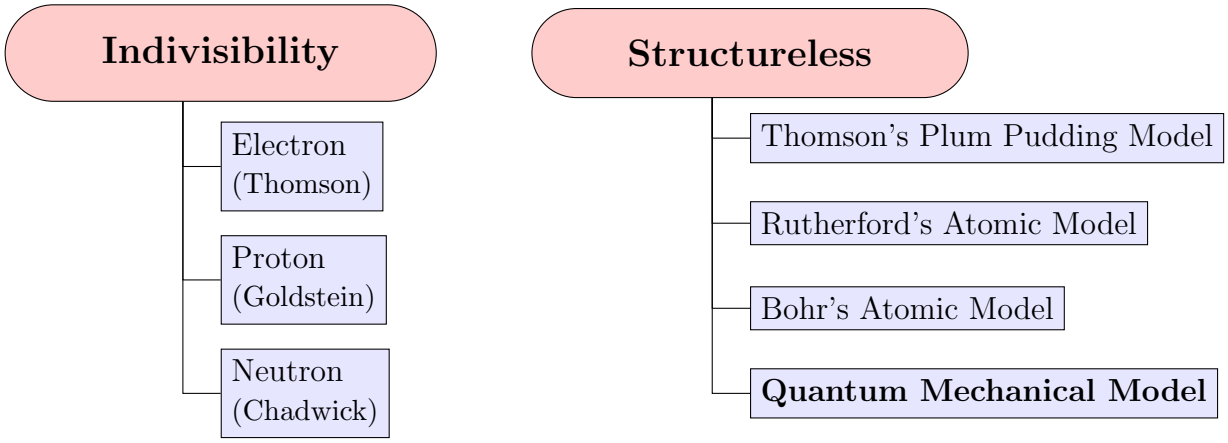
Atomic Structure

Atom: The smallest particle of matter which may or may not stably exist, but can take part in chemical reactions.

Dalton's Atomic Theory

- Matter is made up of a smallest indivisible particle called atom.
- Atoms of same elements are alike in all aspects and atoms of different elements are different in all aspects.
- Atoms can neither be created nor be destroyed. In a chemical reaction, atoms are exchanged to form molecules.



Discovery of an Electron

Discharge Tube Experiment / Cathode Ray Tube

Characteristics of Cathode Rays

1. They are originated from the cathode and move towards the anode. Therefore they are called cathode rays.
2. Cathode rays are made up of negatively charged materiallistic particles, which were later called electrons.
3. Cathode rays travel in a straight line and is deflected by electric and magnetic fields.
4. Cathode rays produce heating effect and they can produce x-rays on striking on surface of hard metal.

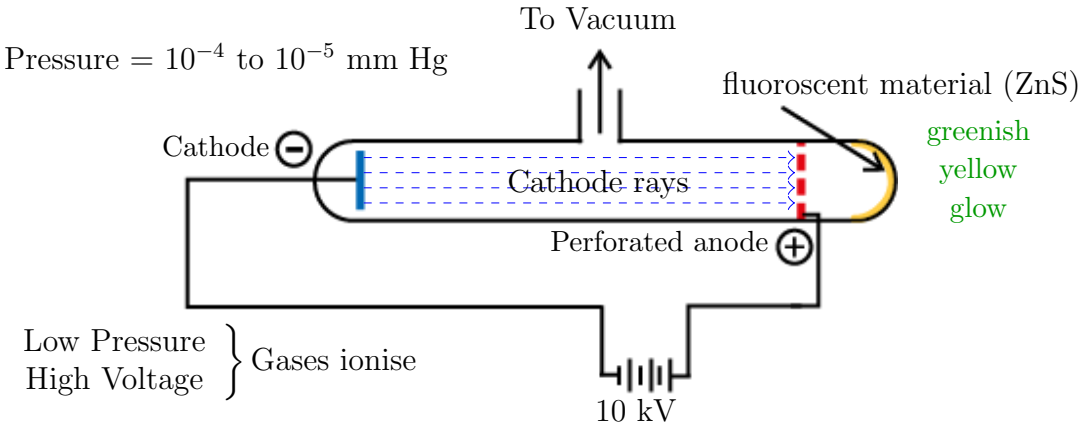


Figure 1: JJ Thomson's Cathode Ray Tube Experiment

Note

- Gases are ionised at low pressure and high voltage.
- Cathode rays consist of electrons ejected from cathode and evolved from ionisation of gases.

Specific Charge ($\frac{e}{m}$ ratio) for Electron

$$\left(\frac{e}{m}\right)_{e^-} = 1.7588 \times 10^{11} \text{C kg}^{-1}$$

Specific Charge does not depend on the nature of gas or nature of electrodes.

Charge and Mass of Electron

The charge of an electron was discovered by Millikan's Oil Drop Experiment.

$$\text{Charge on an Electron} = -1.6 \times 10^{-19}\text{C}$$
$$\text{Mass of an Electron} = 9.1 \times 10^{-31}\text{kg}$$

Discovery of Proton

Characteristics of Anode Rays

1. Anode rays move from the anode to cathode.
2. They travel in a straight line.
3. The e/m values of an anode ray depend on the
    - nature of gas

- nature of electrodes

4. Anode rays consist of positively charged materialistic particles, which in case of Hydrogen is called a proton.

$$\left(\frac{e}{m}\right)_{p^+} = 9.6 \times 10^7 \text{C kg}^{-1}$$

$$\text{Charge on a Proton} = +1.6 \times 10^{-19}\text{C}$$
$$\text{Mass of a Proton} = 1.67 \times 10^{-27}\text{kg}$$

Discovery of Neutron

(Chadwick)

$$^{9}_{4}\text{Be} + ^{4}_{2}\text{He} \longrightarrow ^{12}_{6}\text{C} + ^{1}_{0}\text{n}$$

When a lighter nuclei is bombarded with energetic α particles, a stable nuclei and an unidentified particle is observed. This particle was later known as neutron.

$$\text{Charge on a Neutron} = 0$$
$$\text{Mass of a Neutron} = 1.67 \times 10^{-27}\text{kg}$$

Specific Charge Values

$$e^- = 1.76 \times 10^{11} \text{ C kg}^{-1}$$
$$p = 9.6 \times 10^7 \text{ C kg}^{-1}$$
$$\alpha = 4.8 \times 10^7 \text{ C kg}^{-1}$$
$$n = 0 \text{ C kg}^{-1}$$

$$\boxed{n < \alpha < p < e^-}$$

Q) Find the ratio of e/m of an electron and α particle.

$$= \frac{1.76 \times 10^{11} \text{ C/kg}}{4.8 \times 10^7 \text{ C/kg}}$$
$$= 3.67 \times 10^3$$

Q) An oil drop has -6.39×10^{-19} C of charge. Find the number of electrons.

$$n = \frac{6.39 \times 10^{-19}\ \text{C}}{1.6 \times 10^{-19}\ \text{C}}$$
$$= 4 \text{ electrons}$$

Thomson's Plum Pudding Model

According to Thomson, atoms are assumed to be a sphere in which positive charge is uniformly distibuted and electrons are embedded in this positively charged sphere.

Rutherford's Gold Foil Experiment

1. Most α particles passed through the gold foil without any deflection.
2. A few α particles deflected to a very small angle.
3. Rarely, a very few α particles deflected to a very large angle, i.e. bounced back.

Rutherford's Conclusions

1. An atom has a lot of empty space
2. An atom has a positively charged core at its centre, which was later called the nucleus.
3. The whole mass of the atom is concentrated at the positively charged centre.

Drawback of Thomson's Atomic Model

Thomson's model was unable to explain the Rutherford's Gold Foil Experiment.

Rutherford's Atomic Model

According to Rutherford,

1. All the positive charge and mass of an atom is concentrated in a very small region called the nucleus.
2. The size of the nucleus (diameter) is about 10^{-15} m, which is very small as compared to the diameter of the atom, 10^{-10} m.

$$\boxed{R_N = R_0 A^{1/3}} = 1.25 \times 10^{-15} A^{1/3}$$

3. The electrons equal in number to the net nuclear charge revolve around the nucleus.

4. The centrifugal force arising due to the circular motion of the electrons is balanced by the electrostatic force of attraction.

$$F_{\text{electrostatic}} = \frac{Kq_1q_2}{r^2}$$

$$F_{\text{centrifugal}} = \frac{mv^2}{r}$$